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Review

Unleashing the Hidden Potential: The Transformative Influence of Occupational Health and Safety Education on Chemical Engineers

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ABSTRACT

Occupational Health and Safety (OHS) education plays a crucial role in shaping the professional development of chemical engineers, equipping them with the necessary knowledge and skills to ensure workplace safety and prevent occupational hazards. This manuscript presents a comprehensive review of the impacts of OHS education on chemical engineers, focusing on its role in enhancing awareness, knowledge acquisition, and practical application. The study explores the influence of OHS education on promoting a safety culture, improving risk assessment and management practices, and fostering a proactive approach towards identifying and mitigating occupational hazards. It also investigates the effects of OHS education on job satisfaction, professional growth, and career opportunities within the chemical engineering field. By analyzing relevant literature and case studies, this review provides valuable insights into the positive outcomes resulting from integrating OHS education into the curriculum at universities. The findings emphasize the significance of OHS education in cultivating competent and safety-conscious chemical engineers who contribute to sustainable and responsible industrial practices.

1. Introduction

Considering the occupational accidents that occur in Türkiye, the importance of occupational health and safety (OHS) education will be clear. The beginning of occupational health and safety awareness during the university years will provide convenience in business life, as well as helping to prevent many accidents. Measures and strategies designed to prevent, control, reduce or eliminate occupational hazards and risks have been continuously developed and implemented over the years in order to keep up with technological and economic changes.

The role of education in creating an OHS culture in our country and creating awareness about preventive activities are very important. There are occupational accidents that occur every year as a result of mistakes caused by lack of education [1, 2]. Therefore, with the Law No. 6645 dated 04/04/2015 and the regulation in paragraph (i) of Article 5 of the Higher Education Law No. 2547 in Türkiye, according to the Occupational Health and Safety Law No. 6331 dated 20/06/2012, the course "Occupational Health and Safety" has been made mandatory in faculties that train graduates who can become occupational safety specialists [3]. Thus, young and newly started individuals will start to create measures to be taken against these risks at work by acting more consciously against the risks in the environments where they work.

Chemical engineers study the chemical and physical processes of substances and ensure the more efficient use of products with newly developed technology. Chemical engineering, as in many other engineering fields, requires high attention in the field of occupational health and

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safety [4]. Chemical engineers should act by ensuring the safety of work and life.

With regards to literature reviews, it has been observed that there is a significant gap in studies examining the usefulness of occupational health and safety courses for chemical engineers in their professional careers, as well as the effectiveness of course content. In order to address this deficiency, the present study aims to investigate the effects of the mandatory occupational health and safety course offered in engineering faculties across universities.

The study examines the course content and includes interviews with the Istanbul Branch of the Chamber of Chemical Engineers to assess the impact of this course on experienced chemical engineers in the field. The findings of this research indicate that the occupational health and safety course is indeed beneficial in raising awareness among young chemical engineers entering the workforce [5]. However, it also highlights the need for customizing course content based on different engineering departments and delving into subjects in greater detail, rather than superficially [6]. By investigating these aspects, this study aims to contribute to the understanding of the role and impact of occupational health and safety courses for chemical engineers in academia and business environments.

2. Occupational health and safety (OHS) lecture curriculum

Occupational Health and Safety (OHS) encompasses a series of reviews and practices that aim to ensure employee safety by adhering to statutes and laws focused on mitigating potential accidents and occupational hazards. Türkiye, specifically, introduced Law No. 6645 on 04/04/2015, along with a regulation stated in paragraph (i) of Article 5 of the Higher Education Law No. 2547 [7], making OHS lectures mandatory. By law, starting from 2016, faculties of architecture and engineering were required to incorporate OHS lectures into their curriculum. In a study conducted in 2016, it was observed that 26% of the engineering faculties implemented the course within their programs. However, according to a study conducted in 2018, the rate of implementation for engineering departments was 23%, while compliance with the legislation across all departments remained at 20% [8].

Various universities have different course timetables [9], spanning the first two terms and the last two terms of the standard four-year university education. In the long run, it has been observed that the final two terms of the course are more effective for students. During their internships, students gain valuable experience and practical knowledge that enables them to grasp the course contents better, thus significantly contributing to their professional lives in terms of up-to-date information.

Table 1. Gazi University Engineering Faculty OHS402 lecture syllabus [11]

1. Week	Fire and Fire Protection
2. Week	Explosion and Explosion Protection
3. Week	Occupational Health and Safety in Electric Consisting Works
4. Week	Occupational Health and Safety in Indoor Workplaces
5. Week	Occupational Health and Safety in Working in Pressure Vessels
6. Week	Occupational Health and Safety in High-altitude Works
7. Week	Occupational Health and Safety in Designing, Producing and Using of Work Equipments
8. Week	Occupational Health and Safety in Maintenance and Repair Works
9. Week	Midterm
10. Week	Risk Management Approachs
11. Week	Risk Assessment Methods
12. Week	A Field-Specific Example of an OHS Approach at Work (Construction)
13. Week	A Field-Specific Example of an OHS Approach at Work (Mining)
14. Week	Presentations of Project Studies
15. Week	Finals

The primary objective of OHS lectures can be defined as acquiring an understanding of risk assessment methodologies, learning to identify and manage risks specific to various business types and industries, conducting risk assessments outside their own field, and determining the necessary preventive measures. The students

who undergo these lectures gain valuable skills in risk management, the ability to organize workplaces according to OHS principles, and develop planning skills to prevent potential occupational accidents and diseases in their professional lives [10].

The OHS lecture curriculums published online by two different universities are given below for further discussion. Table 1 displays the lecture syllabus of OHS402 lecture of Gazi University Engineering Faculty.

Table 2. Altınbaş University Engineering Faculty ISG402 lecture syllabus [12]

1. Week	Occupational Health and Safety Services
2. Week	Supervision of the Working Environment, Workplace, Building and its Extensions
3. Week	Identification of Hazards/Risks, Attention and Human Factors
4. Week	Risk Factors
5. Week	Hierarchy of Controls and Transmission of Hazards
6. Week	Fire and Fire Protection, Ergonomics
7. Week	Midterm
8. Week	Occupational Health and Safety in Construction Workplaces, Occupational Health and Safety in Manual Lifting and Transportation Work, Occupational Health and Safety in High-altitude Work
9. Week	Occupational Health and Safety in Mining Workplaces, Occupational Health and Safety in Working in Pressure Vessels
10. Week	Occupational Health and Safety in Agricultural Areas, Occupational Health and Safety in Indoor Workplaces
11. Week	Warning Inspection, Accident Investigation and Report
12. Week	Personal Protective Equipment, Emergency Management at Workplaces
13. Week	Occupational Hygiene, Health Surveillance and Occupational Diseases
14. Week	The Controls to be Carried Out in Terms of Occupational Safety and the Documents to be Issued, the International Ethical Rules for Occupational Health and Safety Professionals

In order to compare the contents of the same lectures of different universities Table 2 is proposed for the evaluation.

When the tables above are examined, it may be resulted that the course contents differ among the universities apart from some major topics such as fire and fire protection, risk assessment, OHS in confined working areas, etc. In addition, these syllabi showed lack at topics such as chemical labeling, safety precautions against hazardous chemicals, chemical laboratory safety, that reveal vital importance for chemical engineering students.

These observations may be interpreted that OHS course should be customized according to different departments of the engineering faculties increasing the efficiency of the professional life and enabling the students to gain more knowledge about their field of work and occupational safety. As the most important target of the lecture is to have OHS culture, the benefits of the lecture will be in harmony with the professional life. Thus, it would be a success for the professional life to make chemical engineers gain awareness of the possible risks in their own working areas and be informed about preventing possible accidents. Also, this point of view may be applied in other departments of the engineering faculties considering their priorities.

3. Impacts of OHS course

The definition of "Occupational Accident" may vary depending on different organizations or legislations, but the underlying meaning remains the same. According to the World Health Organization (WHO), it is described as an event that is not planned in advance and often leads to personal injury, equipment damage, and a temporary halt in production [13]. The International Labor Organization (ILO) defines it as an unexpected and unplanned event that causes specific harm or injury [14]. In Law No. 6331 on Occupational Health and Safety, it is defined as an event resulting in death or a mental or physical disability, occurring in the workplace or due to work execution [15]. While definitions may differ, occupational accidents are essentially unexpected situations causing personal or financial harm. However, it is important to note

that work accidents can be prevented. In such cases, Occupational Health and Safety (OHS) training plays a crucial role in safeguarding individuals working in hazardous areas, including chemical engineers.

Chemical engineers undertake various tasks such as process design, optimization, quality assurance, safety, and environmental quality. They work in laboratory settings as well as chemical production facilities. Project engineers operate in engineering offices, while business engineers work directly in the business field. The scope of work for chemical engineers is vast, including industrial plants, labs, project offices, import-export companies, and various sectors such as petrochemicals, automotive, pharmaceuticals, and more. The risks and potential occupational accidents can differ depending on the equipment used, processes involved, and work environment. Therefore, OHS expertise is crucial for chemical engineers to ensure the safety of themselves and their co-workers. Especially for those in managerial positions, it is essential to inform and raise awareness among their subordinates because protecting lives and ensuring safety is of utmost importance.

Table 3. Chemicals and chemical products manufacturing sector 2010-2021 occupational accidents SSI records [16]

Years	Male	Female	Total
2010	789	44	833
2011	717	47	764
2012	691	53	744
2013	1662	1860	3522
2014	1608	192	1800
2015	1754	230	1984
2016	1914	276	2190
2017	2495	382	2877
2018	2927	461	3388
2019	3269	525	3794
2020	3719	690	4607
2021	4588	743	5331

In other words, the impact of occupational health and safety training for chemical engineers cannot be solely assessed based on occupational accident statistics within their profession. To comprehensively address this impact, it is necessary to analyze the occupational accident data of employees working alongside chemical engineers. In this study, the occupational accident data from the Social Security Institution (SSI) in the chemical and chemical product manufacturing sector between 2010 and 2021 were analyzed, tabulated (Table 3), and interpreted.

In order to accurately interpret occupational accidents, it is crucial to consider multiple parameters. Factors such as the sector's development, the number of workers involved, and the reliability of accident data must be carefully evaluated during the analysis. For instance, according to records declared by SSI, only one out of every ten work accidents in Türkiye is reported [16]. Thus, considering this data, it is possible to draw the following conclusions.

Comparing records from previous years with more recent ones, it is evident that occupational health and safety (OHS) has gained prominence and significance. The chemical industry, which experienced a growth rate of 18.54% in 2019, serves as a prime example of this trend [17]. Thanks to the implementation of OHS laws, employees in this expanding sector are being increasingly protected. Analyzing the data presented in the table, it becomes apparent that there was a significant decline in work accidents after the OHS Law came into effect in 2012. This suggests that prior to this, work accidents were not given adequate attention, and records were not being kept properly.

However, looking at the data after 2012, there is a clear decrease in accidents, which can be attributable to the impact of the OHS Law. Although the number of occupational accidents appears to have increased after the introduction of the compulsory OHS course in 2015, when considering the sector's growth and increased employment, it can be argued that there is a positive momentum in the field of occupational health and safety within the chemical sector.

In a survey conducted with students enrolled in occupational health and safety courses, the majority answered negatively to questions such as "Do you have knowledge about the OHS Law No. 6331?" and "Are you aware of your legal rights in case of workplace accidents?".

However, they responded positively to questions like "Does a focus on OHS lead to increased work efficiency and quality?" and "Should every workplace provide OHS training to workers before they start their jobs?" [18]. In another study comparing students who did and did not take OHS courses, similar questions were asked, and it was observed that students who completed the course demonstrated greater awareness. These results indicate that students gain an understanding of the importance and culture of OHS through these courses. However, despite their interest in the subject matter, students still lack sufficient knowledge regarding the OHS Law and their legal rights. This underscores the need for an improved content in the course material.

4. Customizing OHS course for chemical engineering department

Chemical engineering is widely acknowledged for its extensive practical applications within the field. As part of their academic curriculum, students undergo laboratory courses that provide them within valuable hands-on experience, working extensively with a diverse range of chemicals. It is important to note that these laboratories house an array of potent acids, bases, and other hazardous or irritating substances. Therefore, students must exercise utmost caution when handling these chemicals and comply strictly with Occupational Health and Safety (OHS) regulations [19-21].

Additionally, it is imperative for students to acquire comprehensive knowledge and skills to respond appropriately in the event of accidents or damage to laboratory materials. A thorough review of the existing studies highlighted certain deficiencies in the OHS course specifically tailored for chemical engineering students, particularly in relation to laboratory equipment and chemical aspects [22-25]. Addressing these gaps in curriculum design is crucial, as chemical engineers entering the professional world must possess a thorough understanding of occupational safety and risk mitigation.

By incorporating greater customization into the Occupational Health and Safety (OHS) course to meet the precise needs of chemical engineering, its efficacy can be substantially bolstered. These enhancements will not only help alleviate potential workplace hazards for prospective employees but also foster the cultivation of exceptionally skilled practitioners in this field. These findings carry profound implications for chemical engineers, as they will be equipped to effectively handle real-life situations and facilitate a secure work environment within their respective industries.

5. Conclusion

In summary, our investigation focused on evaluating the efficacy and sufficiency of the Occupational Health and Safety (OHS) course for chemical engineers, as well as the course's subsequent impact on their professional trajectories. This research was motivated by a recognized gap in the literature concerning the influence of the OHS course on both chemical engineers and the chemical industry at large.
Through collaboration with the Union of the Chamber of Chemical Engineers, we engaged in a series of interviews to address this gap comprehensively. Furthermore, our analysis incorporated accident statistics spanning from 2010 to 2021 within the chemical and chemical products industry, sourced from SSI (Social Security Institution). This meticulous data scrutiny enabled us to form a holistic perspective on the potency and effectiveness of the OHS course within the domain of chemical engineering.

The outcomes of our study revealed that the OHS course is indeed successful in cultivating a general awareness surrounding occupational health and safety matters. However, our findings also illuminated noteworthy deficits in the course's theoretical content. Thus, we recommend a thorough revision of the curriculum to rectify these short comings and amplify its overall impact.

Additionally, our exploration indicated that positioning the OHS course during the final two semesters of the undergraduate program yields superior efficiency. This outcome prompts a call for universities to revisit their programs and align the OHS course accordingly.

Furthermore, as part of curriculum reform, we emphasize the importance of tailoring the course content according to the distinct departments within the Faculty of Engineering. Notably, within the realm of chemical engineering, we propose the inclusion of subjects like adept handling of laboratory apparatus, adherence to chemical safety protocols, proficient chemical labeling practices, and preemptive measures against hazardous chemicals. By weaving these elements into the curriculum, the competencies of future chemical engineers can be significantly augmented, ultimately bolstering their capacity to address occupational health and safety concerns in their professional capacities.

Article Information Form

Authors' Contribution

Fatos Ayca Ozdemir Olgun who is the corresponding author of this study, designed the major outline of the study, contributed at writing and revision. Sumeyye Dilek conducted the scientific research, wrote the main text and contributed at the revision of the manuscript.

The Declaration of Conflict of Interest/ Common Interest

No conflict of interest or common interest has been declared by authors.

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